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Publication/Completion Date—(if *In Press,* enter year accepted or completed) September 2018

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Proceedings of the Human Factors and Ergonomics Society 2018 Annual Meeting

DOI or URL to published work (if available) https://doi.org/10.1177/1541931218621468

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Exploring Higher Agency Roles for Learning with Educational Technology and Multimedia

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Educational technologies with multimedia content can support effective learning, but these outcomes are moderated by learners' level of cognitive engagement or self-regulation. As a way to encourage deeper cognitive engagement without redesigning or redeveloping software (e.g., building more prompts, scaffolds, or automated support), this study investigates changing the *role* of the student user. Specifically, this research considers how instituting a "designer" or "teacher" role may inspire better engagement and learning than the default "learner" role. We present the theoretical background, design, and results of an exploratory study of this hypothesis with college students learning about cohesion in writing.

Keywords
educational technology; engagement; multimedia; user experience; writing instruction

INTRODUCTION

Multimedia instructional materials present information in multiple modalities, such as spoken narration combined with text and images (Adesope & Nesbit, 2012; Clark & Mayer, 2016). In many educational technologies, such as intelligent tutoring systems (Kulik & Fletcher, 2016) and automated writing evaluation systems (Shermis & Burstein, 2013), these multimedia lessons are commonly used to communicate tutorials, strategies, procedures, and formative feedback (e.g., Roscoe, Jacovina, Harry, Russell, & McNamara, 2015).

Learning from educational technologies and multimedia requires cognitive engagement (Chi & Wylie, 2014) and self-regulation (Azevedo & Hadwin, 2005). Ideally, learners select, organize, and integrate key ideas in order to retain, apply, and understand that information (Mayer, 2008). They also need to employ meaningful strategies while evaluating and adapting their own performance (Azevedo, Taub, & Mudrick, 2017).

Although developers *intend* for learners to interact with their software constructively—and may include a wealth of scaffolds and prompts (Azevedo & Hadwin, 2005; Quintana et al., 2004)—many students habitually adopt a passive level of engagement. For example, several studies have explored "gaming the system," wherein students exploit hints or other functions to "succeed" without learning (Baker et al., 2013).

Cognitive disengagement might stem from a variety of sources, such as boredom (Baker, D'Mello, Rodrigo, & Graesser, 2010), social media (Aagaard, 2015), or epistemic beliefs (Strømsø & Bråten, 2010). Likewise, researchers have investigated a variety of effective technology innovations to engage learners. For instance, when disengagement is predicted by students' affective states, technologies might automatically detect those emotions and intervene (Calvo & D'Mello, 2010). Students can also be scaffolded to engage in strategies like help-seeking (Aleven, Roll, McLaren, & Koedinger, 2016), deep reasoning questions (Craig, Gholson, Brittingham, Williams, & Shubeck, 2012), and goal-setting (Twyford & Craig, 2016).

Higher Agency Roles for Learning

In this paper, we explore a way to deepen engagement through the *roles* students are given when using educational technologies. Rather than redesigning the software (e.g., to detect unproductive behaviors), which may incur heavy time and financial costs, we may be able to immerse students in alternative roles that naturally induce greater engagement.

For students using educational technologies, the default "learner" role entails acquiring knowledge and skills by using the system as designed. This role may not grant students much *agency*—a sense of identity and autonomy that guides self-directed behavior (Lindgren & McDaniel, 2012; Martin, 2004). Although technologies may be interactive and feature-rich, learners are given few opportunities to take ownership of such interactions. What if students were invited to *critique* or *redesign* the system? What if students could *repurpose* the system to attain additional personal or professional goals?

There are numerous ways to use technology beyond "learning"—users might also practice "designing," "teaching," "marketing," or "critiquing." Integrating these roles into a learning environment may allow students to use educational technologies with greater authority, purpose, or expertise. The current study focuses on two roles—designer and teacher—and draws from *design thinking* and *learning by teaching* research to argue how these roles may be productive.

*Designer role***.** Dym and colleagues (2005) define design thinking as "a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints" (p. 104) Underlying these processes is a mode of thinking that involves analysis, questioning, decision making, and evaluation (Dym et al., 2005; Razzouk & Shute, 2012). In many ways, these processes parallel self-regulated learning (Broadbent & Poon, 2015). Similar to how designers design, we want learners to learn through critical analysis, identifying gaps, strategies, and using feedback to adapt.

*Teacher role***.** Although teachers are not expected to learn from the technologies they provide to students, they must be familiar with content and pedagogy, and be prepared to integrate the technology in the curriculum (Herring, Koehler, & Mishra, 2017; Tondeur et al., 2017). This process of integration involves problem solving, resource management, and questioning of one's own assumptions. As in design, these strategic and reflective processes are representative of deeper cognitive engagement. Research on learning by teaching has found that students who teach their peers can learn more effectively than when they study alone (Duran, 2017; Roscoe, 2014), because explaining to a peer and answering questions promotes metacognition and knowledge-building (Roscoe, 2014). Similarly, some students study harder to help a peer (or simulated student) than they would for themselves (Chase, Chin, Oppezzo, & Schwartz, 2009).

Alternative Hypothesis: Interactions with Prior Ability

Although higher agency roles may inspire deeper cognitive engagement, an alternative hypothesis emerges from issues of cognitive *demand*. The evaluative, generative, and reflective processes evoked by teaching or designing are also cognitively taxing, potentially resulting in distraction or overwhelming cognitive effort. For some learners, taking on these roles might *hinder* performance. Investigations of students' roles and cognitive engagement must thus take into account individual differences related to ability, knowledge, and/or attitudes.

In this study, we focus on *reading ability*, a salient predictor of learning from multimedia (Roscoe et al., 2015; Scheiter, Schüler, Gerjets, Huk, & Hesse, 2014). Multimedia materials present verbal information via both written text and spoken narration, and students' must use their literacy skills to process and integrate each stream of information. Not surprisingly, skilled readers typically outperform less skilled readers in multimedia learning tasks, although all students benefit. An unanswered question is how such effects interact with higher agency roles. Skilled readers may be better prepared to take advantage of increased agency than less skilled readers.

Current Study

The current study explores the hypotheses that higher agency roles for learning with educational technologies can (a) improve learning outcomes and (b) task perceptions (i.e., indicators of deeper cognitive engagement) without redesigning the software itself. Specifically, this study manipulates whether students are given a "learner," "designer," or "teacher" role when learning about writing strategies via multimedia lessons. We further consider (c) how these effects might be influenced by prior reading ability, such as whether more or less skilled readers may benefit differentially from higher agency roles.

METHOD

Participants

Participants were undergraduates (N = 51) from a university in the southwestern United States enrolled in an introductory course on psychology and engineering. On average, students were 21 years of age (M = 21.3, SD = 4.0) with 25.5% female. Most students self-identified as Caucasian/White (45%), but other races/ethnicities were represented: African-American (2%), Asian (13.7%), Hispanic (17.6%), Middle-Eastern (7.8%), Multiethnic (9.8%), or did not identify (3.9%). Over half (56.9%) reported speaking only English, and 43.1% reported speaking English and at least one other language.

The sample included freshmen (35.3%), sophomores (27.5%), juniors (19.6%), and seniors (17.6%), and academic majors from aviation (17.6%), business (5.9%), computing (27.5%), engineering (33.3%), graphics and design (5.9%), life sciences (2%), and social sciences (5.9%).

Learning Materials

Students studied the topic of *cohesion* in writing, including effects on writing quality and strategies for building cohesion. Students learned about cohesion via multimedia lessons obtained from the Writing Pal system (Crossley, Allen, & McNamara, 2016; Roscoe, Allen, Weston, Crossley, & McNamara, 2014). In four lessons, animated characters introduced learners to cohesion along with cohesion-building strategies: *Overview*, *Signpost Strategy*, *Connectives Strategy*, and *Threading Strategy* (Roscoe et al., 2015). All videos were less than five minutes in duration. Prior studies with W-Pal have found that learners make modest gains in strategy knowledge and essay quality (Allen et al., 2014; Roscoe et al., 2015) through using the software.

Conditions

Participants were randomly assigned to one of three conditions: *Learner Role* (n = 18), *Designer Role* (n = 17), and *Teacher Role* (n = 16). Time on task was consistent across all conditions, and all participants encountered the same materials and measures. The manipulation occurred via the instructions given to participants. All activities occurred within an online survey format administered in an on-campus lab setting.

Learner role condition. Participants were given 30 minutes to "review four multimedia educational videos" in order to "learn about cohesion and writing." Along with each video, participants were given a text box to "take notes for learning the information." Instructions included a reminder that "good notes include valuable ideas and concepts." This task entailed studying the lessons, taking notes, and learning the content—business as usual.

Designer role condition. Participants were given 30 minutes to "review four multimedia educational videos" and think about how to "redesign them for college students." Participants were given a text box to "take notes for evaluating and improving the videos to be useful for college students," with a reminder that "good designs include ideas for making materials more functional, usable, and engaging." Participants were told that they would not be personally reprogramming or recreating the lessons during the session.

Teacher role condition. These participants were given 30 minutes to review the videos and "plan a lesson for teaching college students about cohesion and writing." They were given space to "take notes for planning a lesson that explains and demonstrates the information to college students," and reminded that "good lesson plans include clear learning goals and teaching tactics." Participants were told that they would not personally be teaching the lesson during the session.

Measures

Demographics. Participants completed a brief survey of their demographic and academic background.

Reading comprehension. Reading ability was assessed via the Gates–MacGinitie (4th ed.) Reading Test (GMRT, Form S) level 10/12 (MacGinitie & MacGinitie, 1989). The test consisted of 48 multiple-choice questions assessing students' comprehension of 11 short passages. Each passage was associated with two to six questions, which measured both shallow understanding and deeper comprehension based on textual inferences. Participants were administered the standard instructions with up to 20 minutes to complete the test.

GMRT scores were dichotomized via median split to classify participants as *more skilled* (n = 26, M = 38.4, SD = 5.8) or *less skilled* (n = 25, M = 191.1, SD = 5.8) readers, $F(1,49) = 134.84$, $p < .001$, $\eta^2 = .73$. The dichotomized variable facilitates reporting of interactions. Analyses of covariance were also conducted with reading ability as a covariate to confirm observed patterns (not reported).

Knowledge test. Students' knowledge of cohesion was assessed via four open-ended, overlapping probes to elicit an inclusive representation of students' knowledge:

- *Please carefully define the concept of cohesion. What is cohesion? How is writing that is "cohesive" different from writing that is "not cohesive"?*
- *Please carefully explain how cohesion affects the quality of writing. Why does cohesion improve writing quality? Why does a lack of cohesion decrease writing quality?*
- *Please carefully describe strategies that writers could use to make their writing cohesive. What are a variety of ways that writers can build cohesion, and how to they work?*
- *In the past/future, how have/will you check your own writing to make sure it was cohesive?* (wording for this item varied slightly from pretest to posttest)

Responses from all questions were pooled, and credit was given to unique idea units related to three constructs: defining cohesion (*linking of ideas*, *unity*, and *organization*), impact on writing quality (*flow*, *readability*, *understandability*, *on-topic*, and *engaging*), and cohesion strategies (*connective words*, *signposting*, *threading*, *planning*, and *other*). Idea units were determined based on lesson content and prior scholarship on analyzing and teaching cohesion (e.g., McNamara, Louwerse, & McCarthy, 2010; Roscoe et al., 2015). For instance, texts are more cohesive when ideas and themes from one section are clearly related to ideas in other sections, which results in a smoother and more accessible reading experience. Writers can use connective phrases to signal relationships (e.g., *as a result*, *in contrast*), "thread" repeated themes throughout the text, and "signpost" ideas by defining vague terms (e.g., *this* and *that*).

Two researchers independently coded idea units in a subset of 20% of the data. Agreement was tested for each idea unit, and kappa statistics demonstrated strong agreement: *linking of ideas* ($\kappa = 0.70$), *unity* ($\kappa = 0.74$), *organization* ($\kappa = 0.88$), *flow* ($\kappa = 1.00$), *readability* ($\kappa = 0.80$), *understandability* ($\kappa = 0.90$), *on-topic* ($\kappa = 0.89$), *engaging* ($\kappa = 0.86$), *connective words* ($\kappa = 0.88$), *signposting* ($\kappa = 0.83$), *threading* ($\kappa = 1.00$), *planning* ($\kappa = 0.76$), and *other* strategies ($\kappa = 0.89$).

Participants received credit for including an idea unit only once. Thus, the minimum possible score was 0 and the maximum possible score was 13.

Task perceptions. Participants rated whether their task was *appropriate for college students*, *creative*, *easy*, *enjoyable*, *interesting*, and *worthwhile*. All ratings were based on a 6-point scale ranging from "Strongly Disagree" to "Strongly Agree," with higher ratings indicating more positive attitudes.

RESULTS

Knowledge Gains

There was no difference between conditions in pretest knowledge, $F(2,48) = 1.96$, $p = .153$, $\eta^2 = .08$. However, pretest knowledge was positively correlated with reading ability, $r(51) = .58$, $p < .001$. Skilled readers knew more about the topic initially (M = 5.1, SD = 1.7) than less skilled readers (M = 3.1, SD = 2.4), $F(1,49) = 13.15$, $p = .001$, $\eta^2 = .21$.

Table 1. *Mean (and standard deviations) knowledge test scores by role condition and reading ability*

	Role Condition		
Measure	Learner	Teacher	Designer
	Less Skilled Readers		
Total Pretest	2.4 (2.6)	2.5 (2.2)	4.4 (2.0)
Total Posttest	5.7 (2.4)	5.0 (1.4)	4.8 (2.0)
New at Posttest	4.3 (1.8)	3.2 (1.4)	3.0 (2.2)
	More Skilled Readers		
Total Pretest	4.6 (1.9)	5.5 (1.4)	5.6 (1.9)
Total Posttest	6.4 (1.1)	5.8 (1.5)	6.4 (2.0)
New at Posttest	4.3 (1.0)	2.8 (1.4)	3.2 (1.6)

To assess gains, A 2 (test) x 3 (condition) x 2 (reading ability) mixed ANOVA assessed changes in test scores from pretest to posttest as a function of experimental condition and reading ability. Means are reported in Table 1.

There was a significant main effect of test indicating that participants gained in knowledge from pretest to posttest, $F(1,45) = 18.98$, $p < .001$, $\eta^2 = .30$. A non-significant test by condition interaction, $F(2,45) = 2.67$, $p = .081$, $\eta^2 = .11$, hinted that gains may have differed slightly by condition. Inspection of the means suggested that participants who studied in the "learner" role gained more than participants who studied in "teacher" or "designer" roles.

One challenge with open-ended measures is that participants do not always articulate their full knowledge. For instance, when responding to posttest questions, learners may focus on reporting *new* concepts learned while studying rather than "repeating" ideas already given in pretest answers (due to fatigue or perceived efficiency). For this reason, we calculated an additional score based on *new concepts at posttest*. This measure credited students for articulating correct ideas about cohesion that were *not* previously offered in pretest responses.

A significant main effect of condition was observed for new concepts at posttest, $F(2,45) = 3.88$, $p = .028$, $\eta^2 = .15$. Participants who studied with a learner role articulated about one more new idea than participants in other roles, although participants in all conditions expressed new concepts.

Finally, prior reading ability was related to knowledge of cohesion, but did not appear to influence learning or interact

with condition. Collapsing across pretest and posttest, there was a main effect of reading ability, $F(1,45) = 14.62$, $p < .001$, $\eta^2 = .24$. Skilled readers knew more than less skilled readers. However, the two-way interaction between test and reading ability was not significant, $F(1,45) = 2.15$, $p = .150$, $\eta^2 = .05$; nor was the three-way interaction between test, condition, and reading ability, $F(2,45) = 1.33$, $p = .275$, $\eta^2 = .06$.

Task Perceptions

Overall, perceptions of the learning, teaching, or designing tasks were favorable, indicating that participants viewed their tasks as creative, easy, enjoyable, interesting, and worthwhile.

Table 2. *Mean (and standard deviation) task perceptions by role condition and reading ability*

	Role Condition		
Task Rating	Learner	Teacher	Designer
	Less Skilled Readers		
Creative	5.2 (0.7)	4.1 (1.0)	4.6 (1.3)
Easy	5.0 (1.4)	5.4 (0.7)	5.0 (0.5)
Enjoyable	4.6 (1.1)	4.1 (1.0)	4.4 (1.2)
Interesting	4.9 (1.0)	4.1 (1.4)	4.8 (0.8)
Worthwhile	5.2 (0.8)	4.6 (1.1)	4.9 (1.0)
	More Skilled Readers		
Creative	2.3 (0.9)	3.1 (1.8)	3.7 (1.5)
Easy	5.7 (0.7)	5.0 (0.8)	4.8 (0.7)
Enjoyable	3.4 (1.6)	3.1 (1.4)	3.2 (1.4)
Interesting	3.8 (1.6)	3.6 (1.5)	3.4 (1.3)
Worthwhile	4.0 (1.6)	4.0 (1.6)	4.7 (0.9)

Two-way ANOVAs examined task perceptions as a function of condition and reading ability. Means are given in Table 2.

There were no main effects condition (all *p*s > .300). However, more skilled readers perceived their tasks as less creative, $F(1,45) = 21.58$, $p < .001$, $\eta^2 = .32$; less enjoyable, $F(1,45) = 8.82$, $p = .005$, $\eta^2 = .16$; less interesting, $F(1,45) = 7.51$, $p = .000$, $\eta^2 = .14$; and less worthwhile, $F(1,45) = 4.17$, $p = .047$, $\eta^2 = .08$. Notably, skilled readers' perceptions were still favorable, but less strong than less skilled readers.

An interaction between role condition and reading ability was observed only for perceived creativity, $F(2,45) = 3.45$, $p = .040$, $\eta^2 = .13$. Whereas less skilled readers perceived higher creativity in the learner role, skill readers perceived higher creativity in the teacher or designer role.

DISCUSSION

This study explored whether higher agency roles for using educational technology might support improved learning. We also considered the alternative case that such roles might induce overwhelming demands, perhaps making them less suitable for less skilled or struggling learners.

Learning Outcomes and Task Perceptions

Overall, students gained in their knowledge of cohesion, but participants assigned a learner role somewhat outperformed participants given a teacher or designer role. This finding suggests that higher agency roles created either distraction or overload that constrained learning in this context.

Enacting the roles of teacher or designer may have directed participants' attention away from the content and toward more superficial details (e.g., aesthetic, presentational, or structural aspects of the multimedia lessons). For example, designers might have focused on the animation style or narration voices rather than instructional concepts. In the 30 minutes allotted to reviewing the four videos and to take notes, such task-relevant but learning-irrelevant distractions may have been costly.

It was beyond the scope of this paper to analyze the notes taken on each lesson, but future work with those data may explain how learners enacted their tasks. An informal review of notes revealed that some designers did indeed focus on "the robotic sounds of the voices" (i.e., text-to-speech voices) or suggested adding "more animation" or "more graphics."

Another finding is that reading ability was associated with better knowledge of cohesion overall, as expected, but did not seem to influence learning nor interact with different roles. This outcome implies that features of the tasks, rather than differential ability, were most important for learning.

Finally, participants rated their tasks as creative, enjoyable, and worthwhile. Assigned role did not appear to influence these perceptions, but reading ability had an impact—less skilled readers were more positive. Although skilled readers felt that the content was organized and informative, they already knew some of the ideas. The materials may have been too simple for them, perhaps leading to disengagement that offset benefits of higher agency.

Future Directions

Skilled readers perceived more creativity in higher agency roles. Creativity often requires generating, evaluating, and transforming existing ideas (Sawyer, 2011), which are aspects of deeper cognitive engagement. This tentative finding hints that more complex topics or tasks might have elicited stronger differences between higher and lower agency roles, and/or interactions with prior ability. In this study, manipulations were fairly brief and superficial, with the intent of keeping time-on-task and conditions comparable. Consequently, tasks were likely inauthentic in some ways—the "teachers" never had to teach the material; "designers" never had to implement their design suggestions.

In future work, more meaningful tasks can be assigned that enact more authentic role practices. "Teachers" can prepare or deliver an actual lesson (see Fiorella & Mayer, 2014) and "designers" might conduct participatory design (see Könings, Seidel, & van Merriënboer, 2014) with mockups of the technology interface. Finally, instructions may be revised to emphasize more cognitive aspects of the roles and shift attention away from superficial or aesthetic details.

In sum, this exploratory research offered initial insights and constraints regarding the use of higher agency roles to support learning with educational technology and multimedia, and provided useful guidance for the next stages of research.

ACKNOWLEDGMENTS

This research was supported by the ASU Kern Project, and by the Institute of Education Sciences, US Department of Education (R305A120707). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Kern Family Foundation or the IES.

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